

AD-A154 651

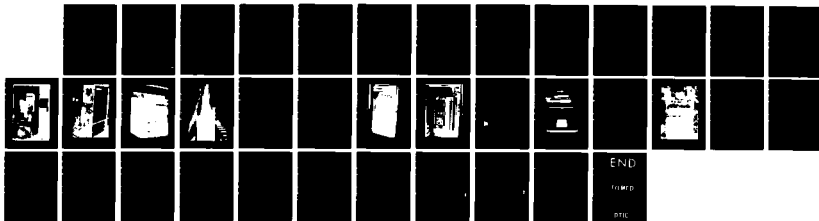
EVALUATION OF A COMMERCIALY AVAILABLE SINGLE BUILDING
EMCS (ENERGY MONITORING CONTROL SYSTEM)(U) NAVAL CIVIL
ENGINEERING LAB PORT HUENEME CA I SANCHEZ ET AL.
FEB 85 NCEL-TR-914

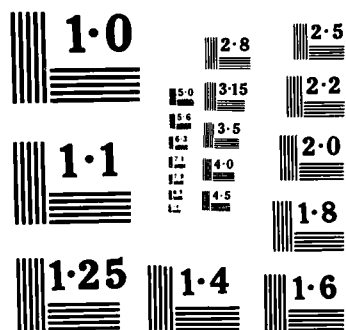
1/1

UNCLASSIFIED

F/G 5/1

NL





NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

AD-A154 651

Technical Report R-914

2

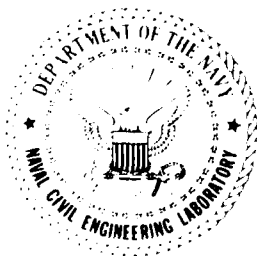
Evaluation of a Commercially Available Single Building EMCS

By Ivan Sanchez, John Franchi and Karlin Canfield

Sponsored by Naval Material Command

February, 1985

DTIC FILE COPY



NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

JUN 5 1985

Approved for Public release; distribution unlimited.

10-011

DTIC
SELECTED
S E D

METRIC CONVERSION FACTORS

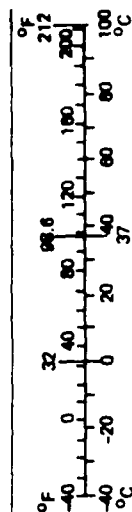
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
in ft yd mi	inches	LENGTH	centimeters	cm
	feet		centimeters	cm
	yards		meters	m
	miles		kilometers	km
in ² ft ² yd ² mi ²	square inches	AREA	square centimeters	cm ²
	square feet		square meters	m ²
	square yards		square meters	m ²
	square miles		square kilometers	km ²
	acres		hectares	ha
oz lb	ounces	MASS (weight)	grams	g
	pounds		kilograms	kg
	short tons (2,000 lb)		tonnes	t
tsp Tbsp fl oz c pt qt gal ft ³ yd ³	teaspoons	VOLUME	milliliters	ml
	tablespoons		milliliters	ml
	fluid ounces		milliliters	ml
	cups		liters	l
	pints		liters	l
	quarts		liters	l
	gallons		liters	l
	cubic feet		cubic meters	m ³
	cubic yards		cubic meters	m ³
°F	Fahrenheit temperature	TEMPERATURE (exact)	5/9 (after subtracting 32)	°C
	Celsius temperature			

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
mm cm m km	millimeters	LENGTH	inches	in
	centimeters		inches	in
	meters		feet	ft
	kilometers		yards	yd
cm ² m ² km ² ha	square centimeters	AREA	miles	mi
	square meters			
	square kilometers			
	hectares (10,000 m ²)			
g kg t	grams	MASS (weight)	square inches	in ²
	kilograms		square yards	yd ²
	tonnes (1,000 kg)		square miles	mi ²
ml l m ³ m ³	milliliters	VOLUME	acres	ac
	liters			
	liters			
	cubic meters			
°C	Celsius temperature	TEMPERATURE (exact)		
	Fahrenheit temperature			

* 1 in. = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price \$2.25, SD Catalog No. C13.10.286.



Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

20. Continued

the attic, stuck dampers, and faulty thermostats. The enormous savings realized after the installation of the SBEMCS resulted in a payback period of 6 months. Prior to this installation, the air handler units ran 24 hours a day, 365 days a year while the boiler and chiller ran continuously during their seasonal operation. It took the coordinated efforts of four people (two public works engineers from the NWC and an engineer and a technician from NCEL) to install and program the SBEMCS. The installation of this system took less than 2 weeks and energy savings started immediately. This report documents the installation and evaluation of the SBEMCS installed at the Thompson Laboratory.

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A/1	



Library Card

Naval Civil Engineering Laboratory
EVALUATION OF A COMMERCIALY AVAILABLE SINGLE BUILDING
EMCS (SBEMCS), (Final) by Ivan Sanchez and John Franchi

TR-914 29 pp illus February 1985 Unclassified

1. EMCS 2. Energy conservation 1. ZO371-01-221C

The Navy is investigating new ways to reduce energy consumption at Naval bases throughout the world. At the Naval Weapons Center, China Lake, Calif., 75% energy savings were achieved at the Thompson Laboratory by installing a commercially available single building energy monitoring control system (SBEMCS). Part of these savings was the result of identifying other problem areas during the installation such as broken ducting in the attic, stuck dampers, and faulty thermostats. The enormous savings realized after the installation of the SBEMCS resulted in a payback period of 6 months. Prior to this installation, the air handler units ran 24 hours a day, 365 days a year while the boiler and chiller ran continuously during their seasonal operation. It took the coordinated efforts of four people (two public works engineers from the NWC and an engineer and a technician from NCEL) to install and program the SBEMCS. The installation of this system took less than 2 weeks and energy savings started immediately. This report documents the installation and evaluation of the SBEMCS installed at the Thompson Laboratory.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER TR-914	2. GOVT ACCESSION NO. DN387288	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EVALUATION OF A COMMERCIALY AVAILABLE SINGLE BUILDING EMCS (SBEMCS)		5. TYPE OF REPORT & PERIOD COVERED Final; Oct 1981 - Sep 1984
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Ivan Sanchez, John Franchi and Karlin Canfield		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS NAVAL CIVIL ENGINEERING LABORATORY Port Hueneme, California 93043		10. PROGRAM ELEMENT PROJECT, TASK AREA & WORK UNIT NUMBERS 64710N; Z0371-01-221C
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Material Command Washington, DC 20360		12. REPORT DATE February 1985
		13. NUMBER OF PAGES 29
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS (of this report) Unclassified
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. ABSTRACTS (continue on reverse side if necessary and identify by block number) EMCS single building controller, energy conservation, energy savings, SBEMCS - single building energy monitoring control system.		
20. ABSTRACT (continue on reverse side if necessary and identify by block number) The Navy is investigating new ways to reduce energy consumption at Naval bases throughout the world. At the Naval Weapons Center, China Lake, Calif., 75% energy savings were achieved at the Thompson Laboratory by installing a commercially available single building energy monitoring control system (SBEMCS). Part of these savings was the result of identifying other problem areas during the installation such as broken ducting in continued		

DD FORM 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

CONTENTS

	Page
INTRODUCTION	1
BACKGROUND	1
DISCUSSION	2
BOILER CONTROL	4
CHILLER CONTROL	5
SYSTEM COST	6
CONCLUSIONS	6
REFERENCES	7
APPENDIX - Details on the Hardware and Software of the AC256 . . .	A-1

INTRODUCTION

The Navy is investigating new ways to reduce energy consumption at Navy Bases throughout the world. At the Naval Weapons Center, China Lake, Calif., 75% energy savings were achieved at the Thompson Laboratory by installing a commercially available single building energy monitoring control system (SBEMCS). Part of these savings was the result of identifying other problem areas during the installation such as broken ducting in the attic, stuck dampers, and faulty thermostats. The enormous savings realized after the installation of the SBEMCS resulted in a payback period of 6 months. Prior to this installation the air handler units ran 24 hours a day, 365 days a year while the boiler and chiller ran continuously during their seasonal operation.

It took the coordinated efforts of four people, two public works engineers from the NWC and an engineer and a technician from NCEL, to install and program the SBEMCS. The installation of this system took less than 2 weeks and energy savings started immediately. This report documents the installation and evaluation of the SBEMCS installed at the Thompson Laboratory. Results such as these can be achieved at most facilities.

BACKGROUND

As a result of the energy crisis of 1973, energy conservation targets were established for Navy shore activities. To meet these targets, many large activities are considering the installation of computerized energy monitoring and control systems (EMCS). These systems promise long term energy controls with limited manpower resources, but have the disadvantage of high initial costs and are primarily feasible for large installations only. Smaller activities have the option of utilizing single building EMCS (SBEMCS). (See Reference 1 for guidelines on the selection and implementation of SBEMCS.) These smaller systems have the advantage of lower initial costs, and the ability to be integrated into a larger EMCS network if one is to be installed at a later date.

The Naval Civil Engineering Laboratory (NCEL) has been furthering the development of SBEMCS. Their first effort, an intelligent building controller (ITC), was described in Reference 2. The original ITC validated the basic concepts of a SBEMCS, but unfortunately the unit was not as reliable or maintainable as desired, and the decision was made to replace the ITC with an NCEL assembled unit using single board computer technology. The development, installation, and resultant performance of this unit is described in Reference 3. Reference 4 documents the use of one of the first commercially available SBEMCS, the Andover Controls "Sunkeeper."*

*The selection of Andover Controls does not imply endorsement by the government. Andover Controls is one of many different single building controller manufacturers (see Reference 5) and may not be better or worse than any other controller with similar characteristics.

Numerous manufacturers are presently supplying SBEMCS. The recently developed SBEMCS are very versatile and efficient energy management systems. NCEL was tasked to buy, install, and evaluate at selected sites two of the recently developed commercially available SBEMCS. NCEL personnel then were to determine the capability of these systems in assisting the Navy to meet the energy conservation targets. The Naval Weapons Center (NWC) at China Lake, California, is the location where the first SBEMCS was installed under this effort. The Trident Submarine Base in Georgia is the next location where a SBEMCS is scheduled to be installed. NWC, China Lake (a high desert location) and the Navy base in Georgia (a high humidity area) were selected based on their different temperature and humidity demands on the SBEMCS.

DISCUSSION

NCEL and NWC, China Lake, in this joint effort selected Building 31433, the Thompson Laboratory, as the evaluation site. This building is 20,000 square feet in size. The air-water Heating, Ventilation, and Air Conditioning (HVAC) system consists of:

1. One 160-ton Chiller, model no. 19DG160, manufactured by the Carrier Air Conditioning Company (Figure 1).
2. One boiler, model no. 309, manufactured by National (Figure 2).
3. Four air handler units (AHUs), with 20-, 20-, 15-, and 10-hp electric motors, respectively (Figures 3 and 4).

The Thompson Laboratory has two methods of controlling the temperature requirements: (1) AHUs and a chiller during the hot weather from May through September, and (2) AHUs and a boiler during the cold weather from November through April.

The AHUs have to be operational year-round to circulate outside air into the occupied building in accordance with ASHRAE standards. NWC, before the installation of the SBEMCS, allowed NCEL to install an energy data acquisition system (DAS) in FY82. Using the accumulated data, NCEL was able to compare the usage before and after the installation of the SBEMCS. The installation of the SBEMCS and the DAS was performed by NCEL personnel. All of the specifications for the control strategies were done by NWC.

Before the installation of the SBEMCS, the HVAC system was in operation 24 hours a day. An energy profile of the AHUs prior to conservation action is shown in Figure 5. At the time these data were gathered, the average daily energy consumption by the AHUs was 700 kW-hr. The first energy conservation effort at the Thompson Laboratory by NWC consisted of changing the pulley ratio on the four AHUs electric motors. The AHU's fan speed was decreased and consequently the AHU's energy usage was reduced as shown in Figure 6. The air volume rate per unit of time (cfm) decreased by 30% and the energy consumption by 43%. NWC was careful to maintain the circulating air volume necessary to comply with the requirements as stated in the ASHRAE standards.

The second energy conservation effort at the Thompson Laboratory consisted of the installation by NCEL personnel of a SBEMCS (an Andover Controls AC256M master unit) (Figures 7 and 8). Details on the hardware and software are given in the Appendix.

On January 28, 1983, the AC256M began controlling the four AHUs at the Thompson Laboratory (Figure 9) with a simple program similar to the one shown in the Appendix. Four sensors (Figure 10) were mounted in the hallway of the laboratory to measure the temperature in the four different zones of the building. An indoor/outdoor sensor (Figure 10) was mounted outside the Thompson Laboratory behind air handler unit No. 1 to monitor outside air temperature. Solid state relays (Figure 11) were used to control the AHUs, chiller and boiler. Instead of the AHUs running 24 hours a day, 365 days a year, they were allowed to run for only 10 hours a day, and were shut off on weekends as well as holidays. Four auxiliary switches were mounted in the hallway of the Thompson Laboratory to control the four AHUs individually in the event personnel wished to work overtime or on weekends. By depressing the momentary-on switch the respective AHU will run for an additional hour. If you depress the switch three times, the AHU will run for an additional 3 hours, etc.

The AHU's resultant energy usage was reduced further as shown in Figure 12. Table 1 shows the energy savings accomplished by doing a scheduled start/stop control on the AHU before and after replacing the pulleys.

Table 1. Thompson Laboratory Electric Consumption/Cost: Four Air Handler Units

Action	Average Usage (kW-hr/yr)	Percentage Energy Saved (%)	Annual Dollar Savings (\$)
Original (continuously running)	255,500		^a
After fan pulley change	150,380	43	10,965
After EMCS and pulley change	49,640	80	20,400

^aOriginal cost was \$25,500 annually

Energy conservation with the SBEMCS controlling the AHUs is limited due to the air circulation requirements of the outside air. Another control strategy that could be implemented is an economizer. An economizer will work in conjunction with the AHUs and the outside air dampers. Basically the AC256M will sense the inside and outside air

temperatures and determine if the cooling or heating requirement can be satisfied with the outside air. The AC256M will send a control signal to position the dampers fully open when the outside air is sufficient to warm or cool the building. Using this strategy, the chiller or boiler could stay off for longer periods of time when the weather conditions are favorable, such as in the transition period between seasons when mild temperatures occur.

BOILER CONTROL

In the past it was thought that cycling a boiler on and off would have an adverse effect on the boiler's life expectancy. Recent information obtained by boiler experts at NWC has determined that cycling the boiler once a day would not affect in any way the operation of the boiler. Samuel G. Dukelow, an instructor in boiler control for the Instrument Society of America, has also emphasized that it does not affect a boiler to be shut down periodically, and cites the fact that many utility companies shut down their boilers every day to save energy. Mr. Dukelow's expertise is backed up by 38 years of experience with Bailey Controls Company, a subsidiary of Babcock and Wilcox Company.

By April of 1983, the boiler at the Thompson Laboratory was under a scheduled start/stop control strategy. The boiler is operated by propane gas (Figure 13). Table 2 compares the last 3 years of propane usage. It can be observed that in the month of April, when the boiler was under computer control, a lower amount of propane was used. This was achieved in spite of the higher heating degree days as compared with the previous 2 years.

Table 2. Thompson Laboratory
Heating Fuel Usage

Year	Heating Degree Days	Propane Usage (gallons)
1981	1341	25,100 ^a
1982	1715	12,800 ^b
1983	1707	9,000 ^c

^aOriginal pneumatic system

^bWith new pneumatic system

^cAfter installing EMCS/last
2 months of heating season
(April and May)

CHILLER CONTROL

An energy profile of the chiller is shown in Figure 14. The chiller was allowed to run 24 hours/day with the AHUs before the installation of the SBEMCS. The installed SBEMCS (AC256) controls the chiller with an optimum start/stop control strategy. Running the chiller in an optimum start/stop control strategy results in turning the chiller off in the afternoon, and on early the next morning. When the chiller is turned on early in the morning, additional work is necessary to cool the water in the system. The chiller will load to a point close to its maximum capacity in order to satisfy the higher cooling demand. At this point the chiller at the Thompson Laboratory is drawing approximately 250 amps at 208 VAC. The chiller efficiency decreases as the overall result of sudden chiller loading.

The AC256 can implement a soft-loading sequence for solving the sudden demand created by the chiller. This is done by locating two load limit switches on the chiller vanes. These switches tell the AC256 when the chiller has been loaded to a specific level. The two settings selected were at 160 amps and 210 amps. By reading the vane limit switches, the AC256 can now tell how much the chiller is loaded. As soon as the AC256 detects the first switch closure the chiller is using about 160 amps. The vane stepper motor is disabled and the chiller is forced by the AC256 to stay at that constant load for a programmable amount of time. A similar condition occurs for the second limit (210 amps). In about 1-1/2 hours the "soft-loading" sequence is over and the AC256 returns to the chiller the capability to load by itself. After contacting several chiller manufacturers, it was determined that there is no soft-loading system available on the market. A patent application has been filed at NWC for the soft-loading system developed at the Thompson Laboratory.

An energy profile of the chiller under an optimum start/stop control strategy and the newly developed soft-loading sequence is shown in Figure 15. Original energy consumption and cost is compared in Table 3 to energy consumption and cost savings after installation of the SBEMCS.

Table 3. Thompson Laboratory Electrical Consumption/Cost Chiller Unit

[Cost saving is approximately 80%]

System	Average Usage (kW-hr/yr)	Annual Dollar Savings (\$)
Original	232,800	^a
After Installing EMCS	46,400	14,100

^aOriginal cost was \$17,600.

SYSTEM COST

Table 4 shows a summary of the system cost. A total of approximately \$20,000 was expended for the acquisition and installation of the entire system. At the Thompson Laboratory the pay-back period was 6 months. The pay-back period at this site was short because of the tremendous energy savings accomplished. Single building controllers cannot be applied everywhere. Ideally, they should be applied in buildings where there is only one shift and there is no critical equipment conditioning requirements or the electronic equipment in the building has a separate air conditioning system. The one working shift means that the HVAC system is active for less than 10 hours. Maximum energy conservation exists when the HVAC system is shut-off completely.

Table 4. Thompson Laboratory Energy
Conservation Efforts Simple
Payback Period: 6 Months

Item	Dollars (\$)
Systems Costs	
Hardware	9,750
Installation	10,200
Total	19,950
Dollar Savings (annual)	38,300

CONCLUSIONS

Single building controllers make available to the user a wide range of energy management strategies such as scheduling, optimum start/stop, demand control, duty cycling, chiller/boiler optimization, enthalpy, and lighting control. Characteristics of good single building controllers are:

1. Distributed control - buy just the system your building needs.
2. Start with a few inputs and outputs and then expand.
3. Sophisticated computer power that is quick and simple to program.
4. Units are easily set up and programmed by the user.
5. Modular design for proven reliability; easy to install, expand, maintain, and service.
6. Remote communication with the unit over phone lines.
7. Units provide reports such as status, alarms, histories and routine.

8. Direct digital control of temperature, humidity and air movement.

A direct result of the successful application of the SBEMCS in the Thompson Laboratory is the additional installation of SBEMCS throughout the entire NWC at China Lake. With a total energy bill of 10 million dollars a year, public works engineers are estimating savings of 30% annually, 3 million dollars a year, using SBEMCS.

A few basic concepts have been illustrated with the Thompson Laboratory effort:

- (1) Determine existing conditions (metering and surveys)
- (2) Determine actual needs (ASHRAE standards, Navy guidance)
- (3) Repair inoperative equipment (Repairing duct work, dampers and thermostat)
- (4) Modify equipment to meet requirements (change AHU's pulleys to provide minimum air recirculation)
- (5) Select energy conservation strategies (scheduled start/stop and chiller soft-loading)
- (6) Install controller with cooperation of building occupants (installations of AC256)
- (7) Monitor operation to determine savings (metering)

REFERENCES

1. Naval Civil Engineering Laboratory. Contract Report CR 83.037: Guidelines on the selection and implementation of single building EMCS. Dayton, Ohio, Stan and Associates, Inc., Aug 1983.
2. _____. Technical Note TN-1588: EMCS modules/intelligent time clock (ITC), by Dallas Shiroma. Port Hueneme, Calif., Sep 1980.
3. _____. Technical Note N-1663: Utilizing the optimum start/stop control strategy for heating NCEL, by Ivan Sanchez. Port Hueneme, Calif., Apr 1983.
4. _____. Technical Note TN-1678: Installation of a SBEMCS at PWC China Lake by Karlin Canfield. Port Hueneme, Calif., Sep 1983.
5. _____. Contract Report CR 82.028: Controlling energy consumption in single buildings. Atlanta, Ga., Newcomb and Boyd Consulting Engineers, Jul 1982.

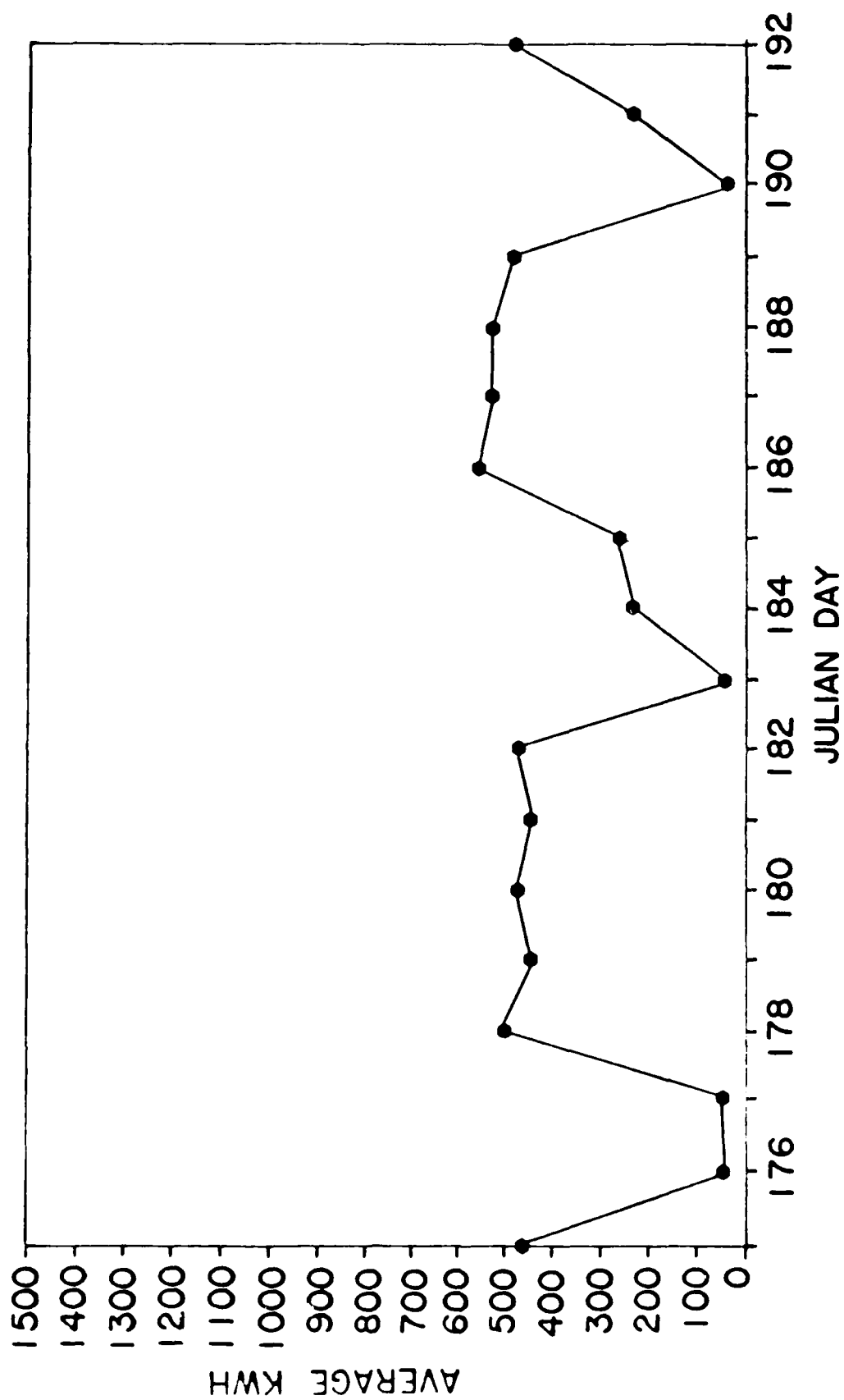


Figure 15. Thompson Laboratory, NWC China Lake AHUS chiller consumption (after EMCS).

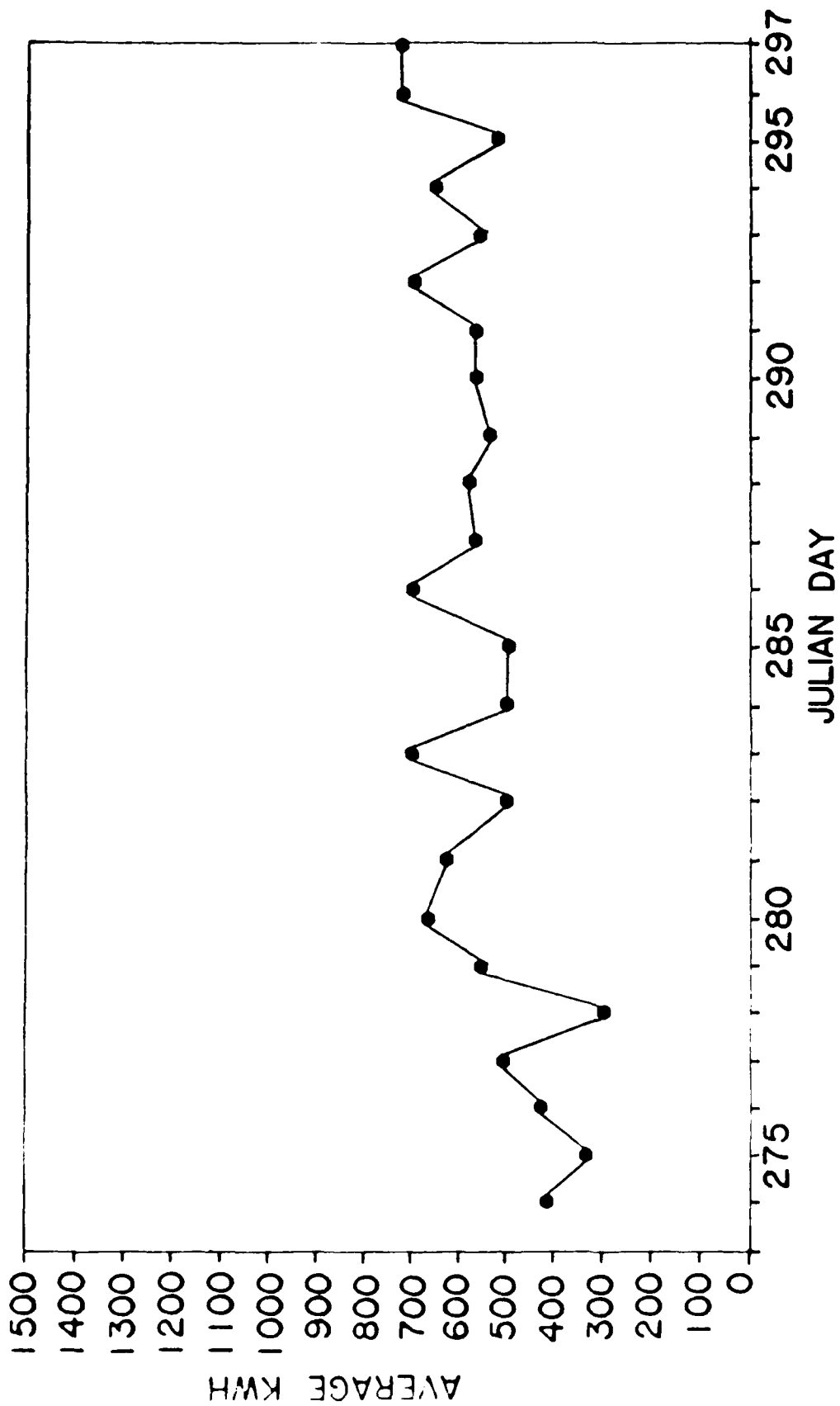


Figure 14. Thompson Laboratory, NWC China Lake AHUS chiller consumption (prior to EMCS).



Figure 13. Gas meter used to measure propane usage of boiler.

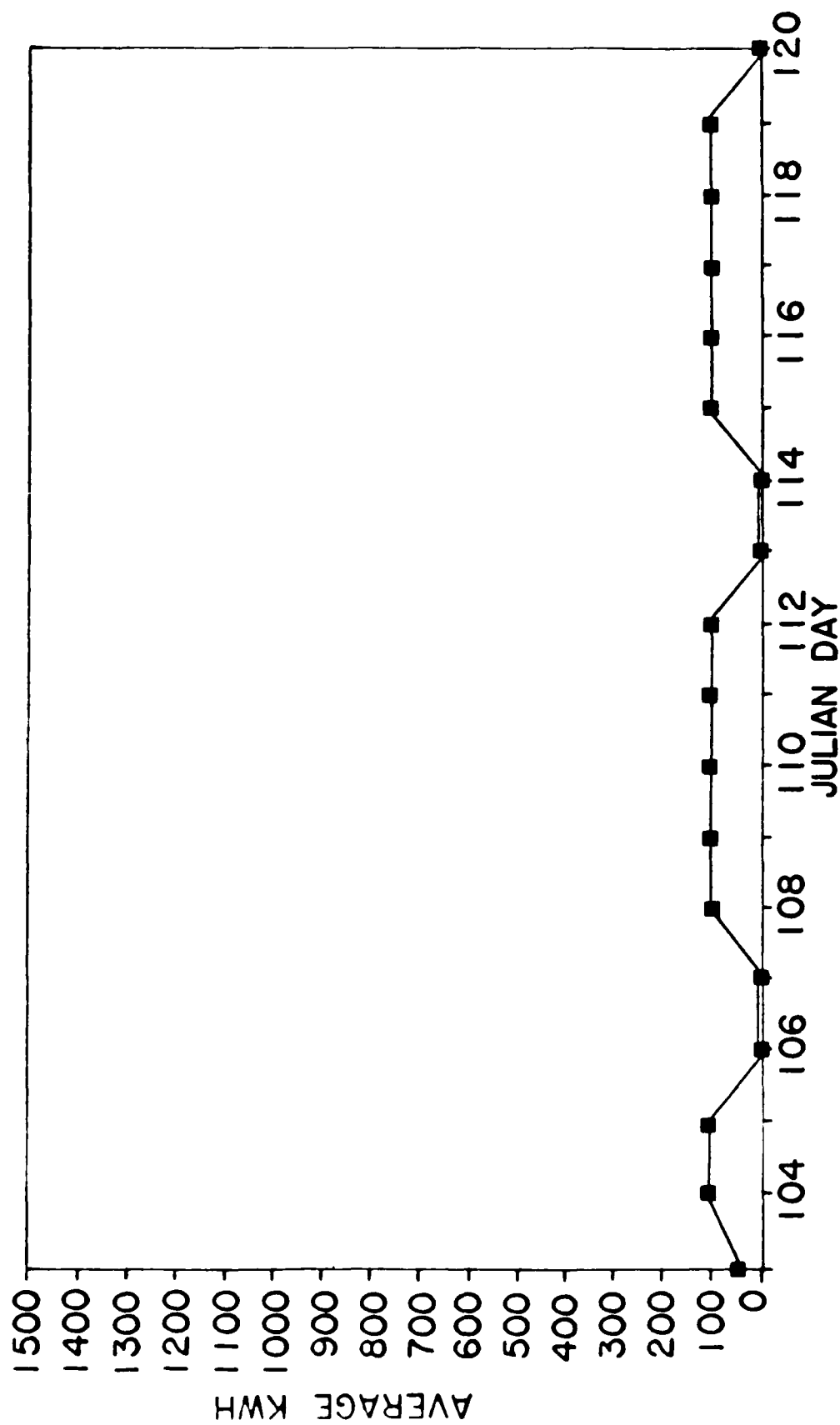


Figure 12. Thompson Laboratory; NWC China Lake AHUS consumption (after pulley change/EMCS installation).

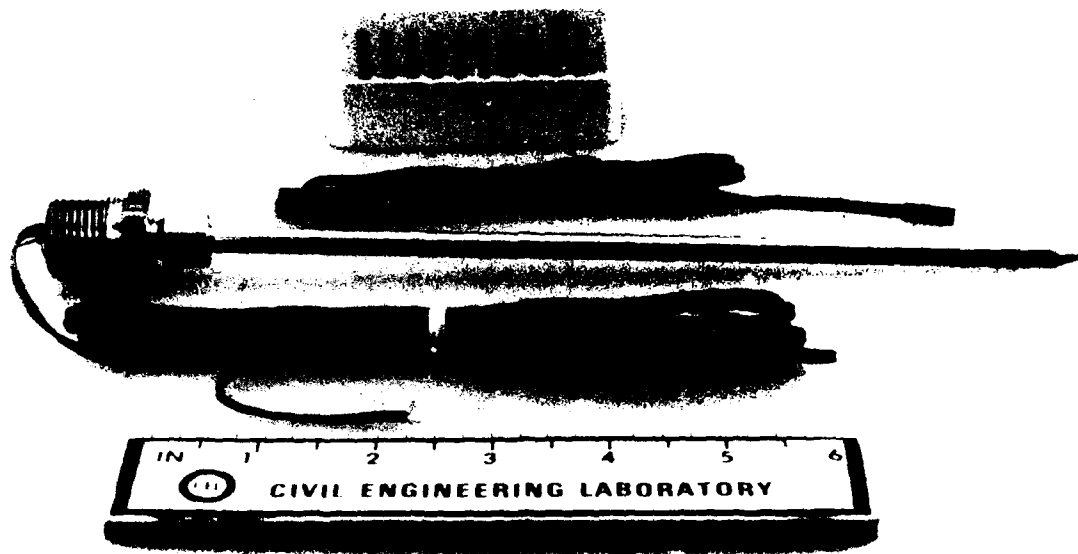


Figure 10. Indoor and outdoor temperature sensors.

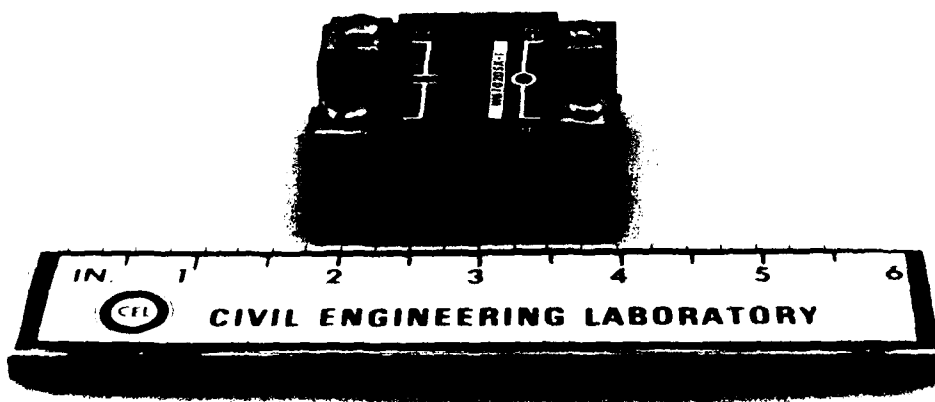


Figure 11. Solid state relay used to control AHUs, chiller and boiler.

RS232 COMMUNICATION

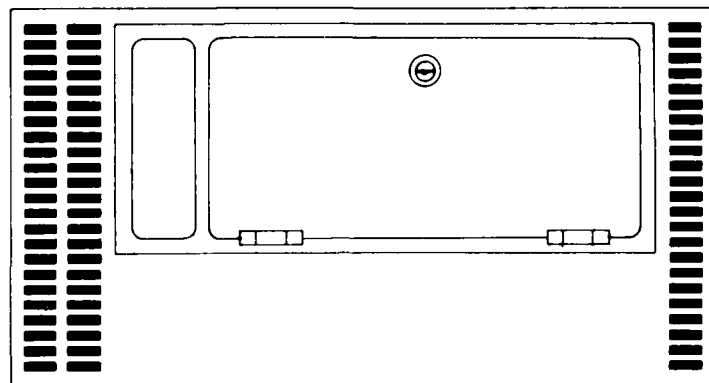


INPUTS

SOFTWARE INPUTS

REAL TIME CLOCK/CALENDAR,
INTERNAL FLAGS, TIMERS

OUTPUTS



ZONE 1 (TEMP)
ZONE 2 (TEMP)
ZONE 3 (TEMP)
ZONE 4 (TEMP)
OUTSIDE AIR (TEMP)
CHILLER (PULSE)
BOILER (PULSE)

AIR HANDLER NO. 1
AIR HANDLER NO. 2
AIR HANDLER NO. 3
AIR HANDLER NO. 4
CHILLER
BOILER

Figure 9. Block diagram of AC 256-M at Thompson Laboratory.

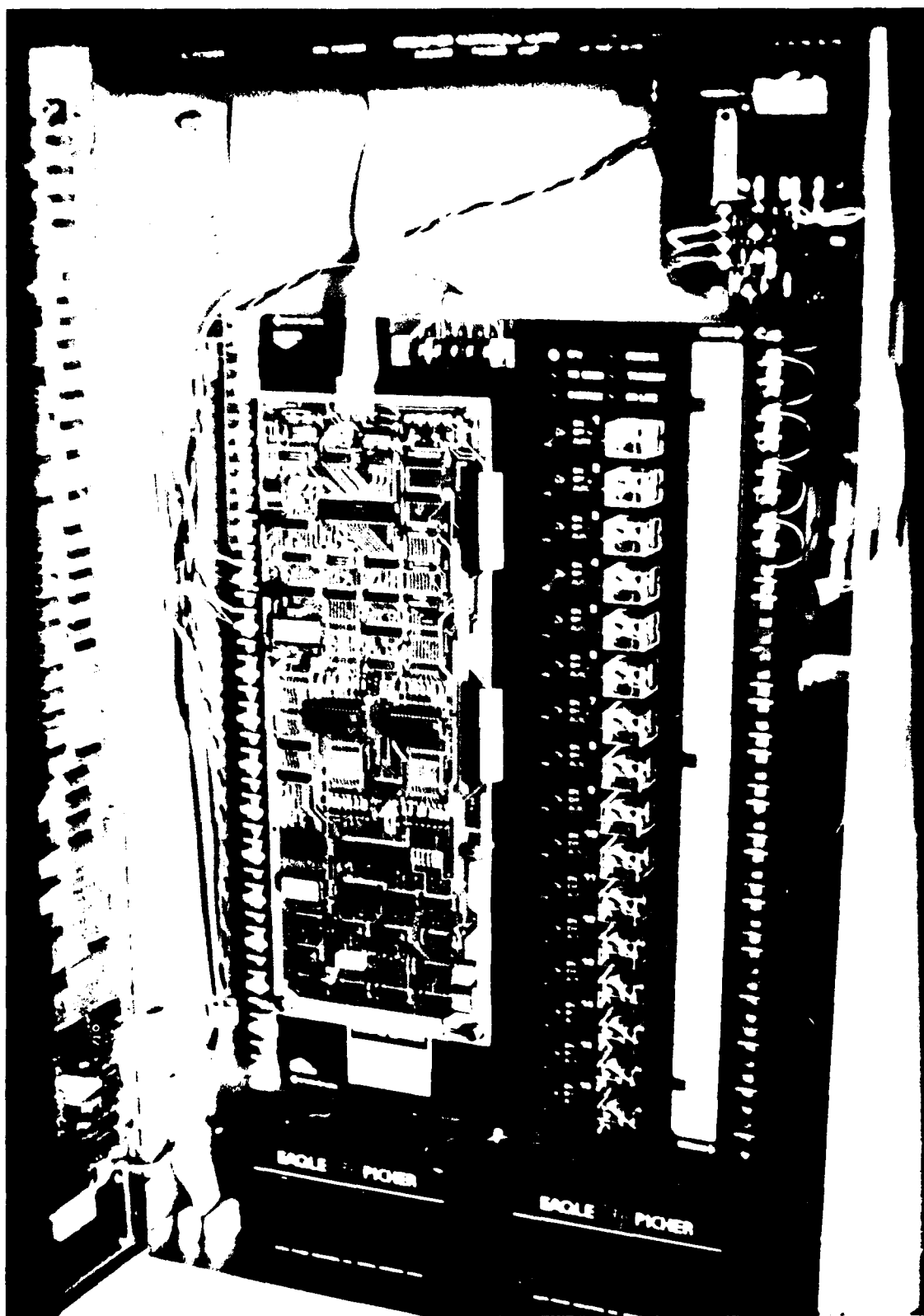


Figure 8. CIU and IOU boards. Andover controls 256-M.



Figure 7. SBEMCS Andover controls 256-M.

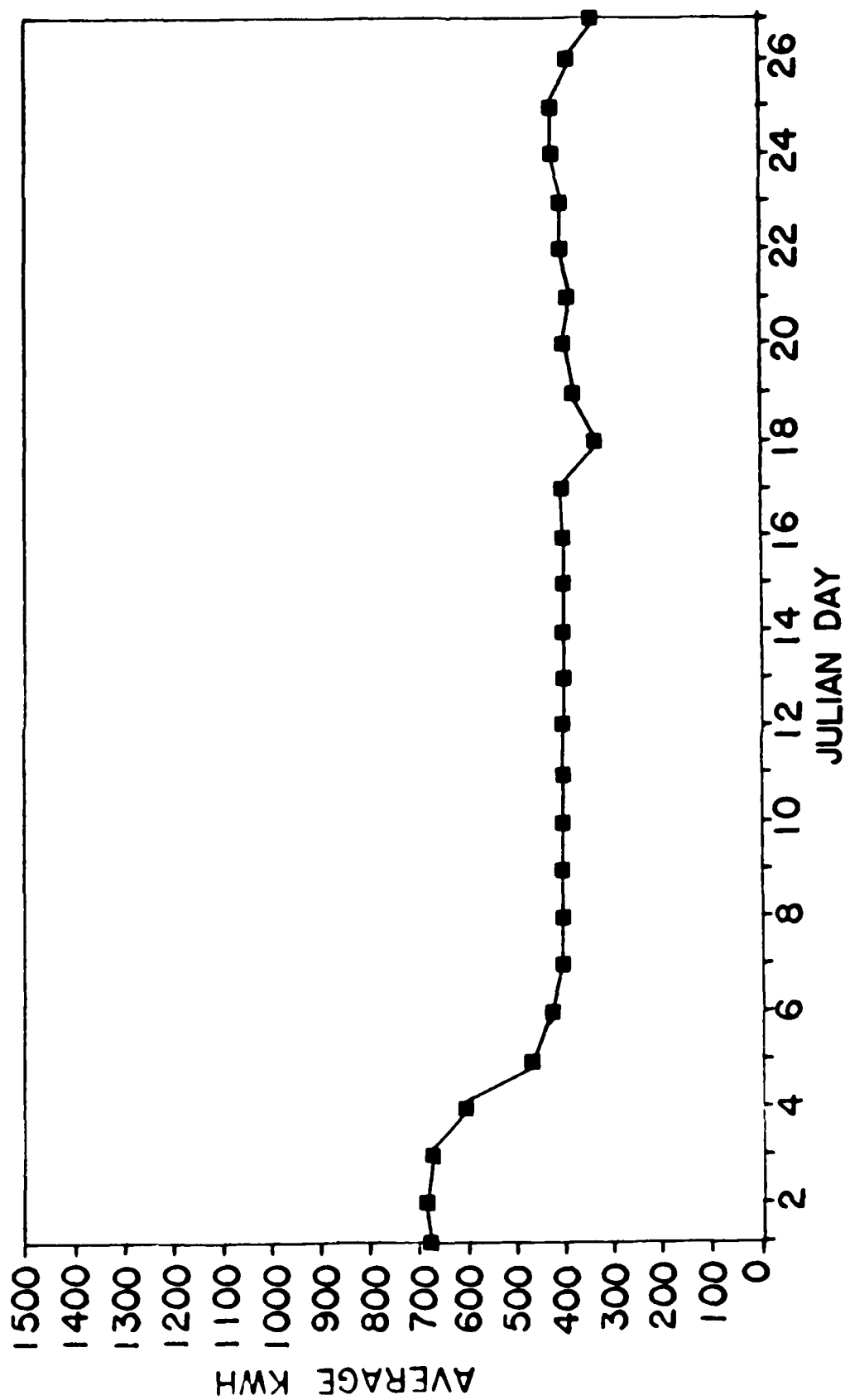


Figure 6. Thompson Laboratory, NWC China Lake AHUS consumption (after pulley change).

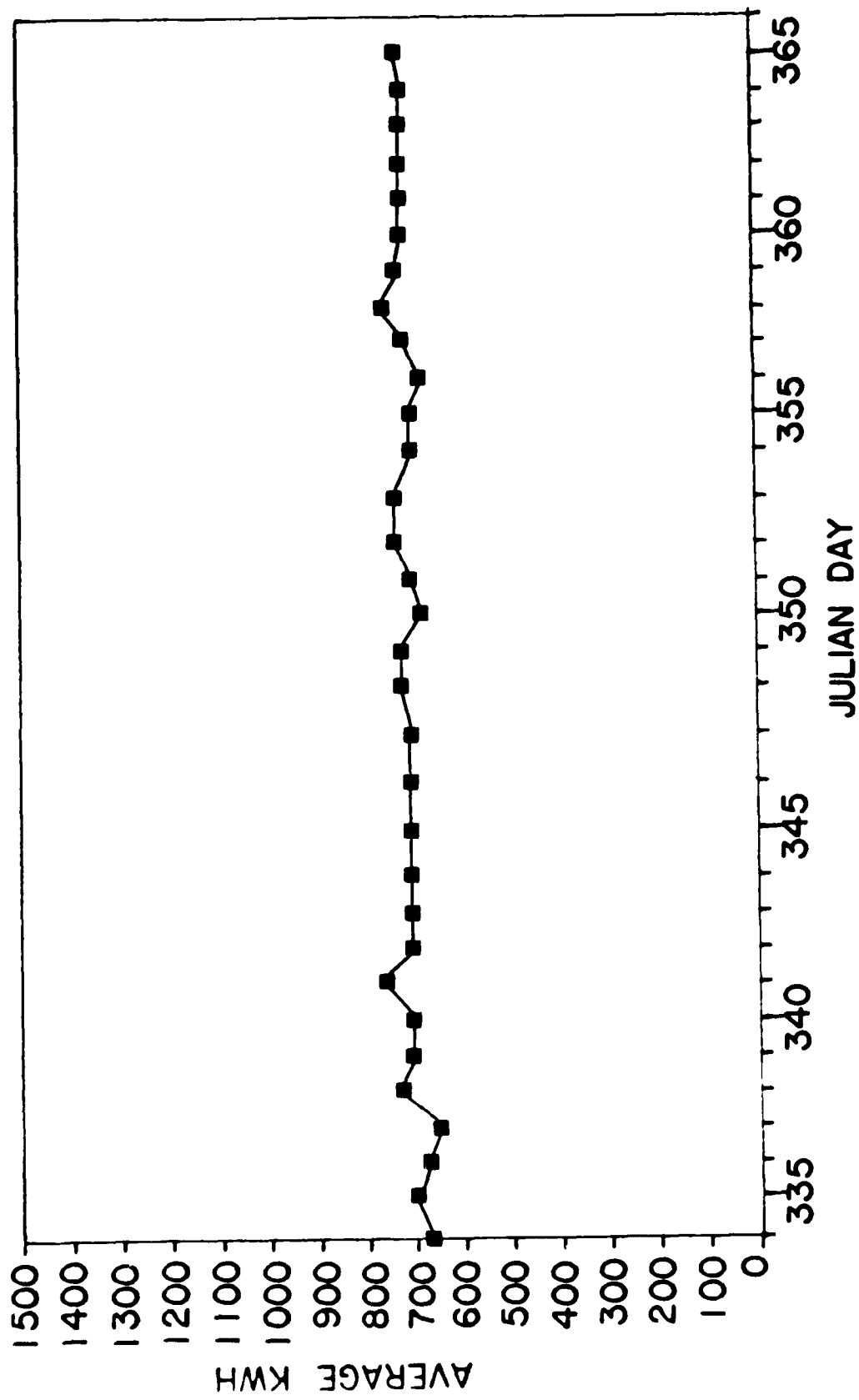


Figure 5. Thompson Laboratory, NWC China Lake AHUS consumption (prior to changes).

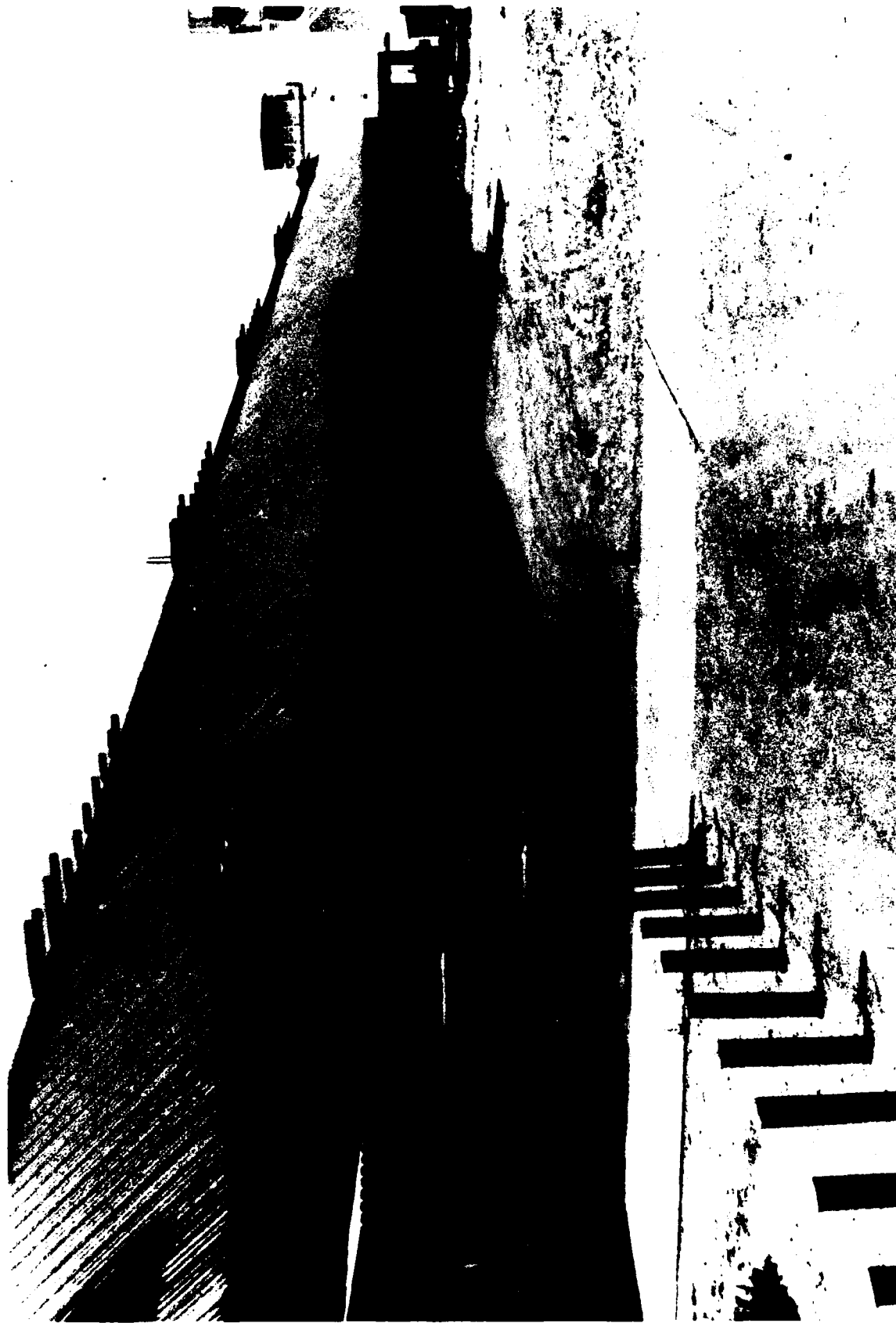


Figure 4. Four air handler units at the Thompson Laboratory.

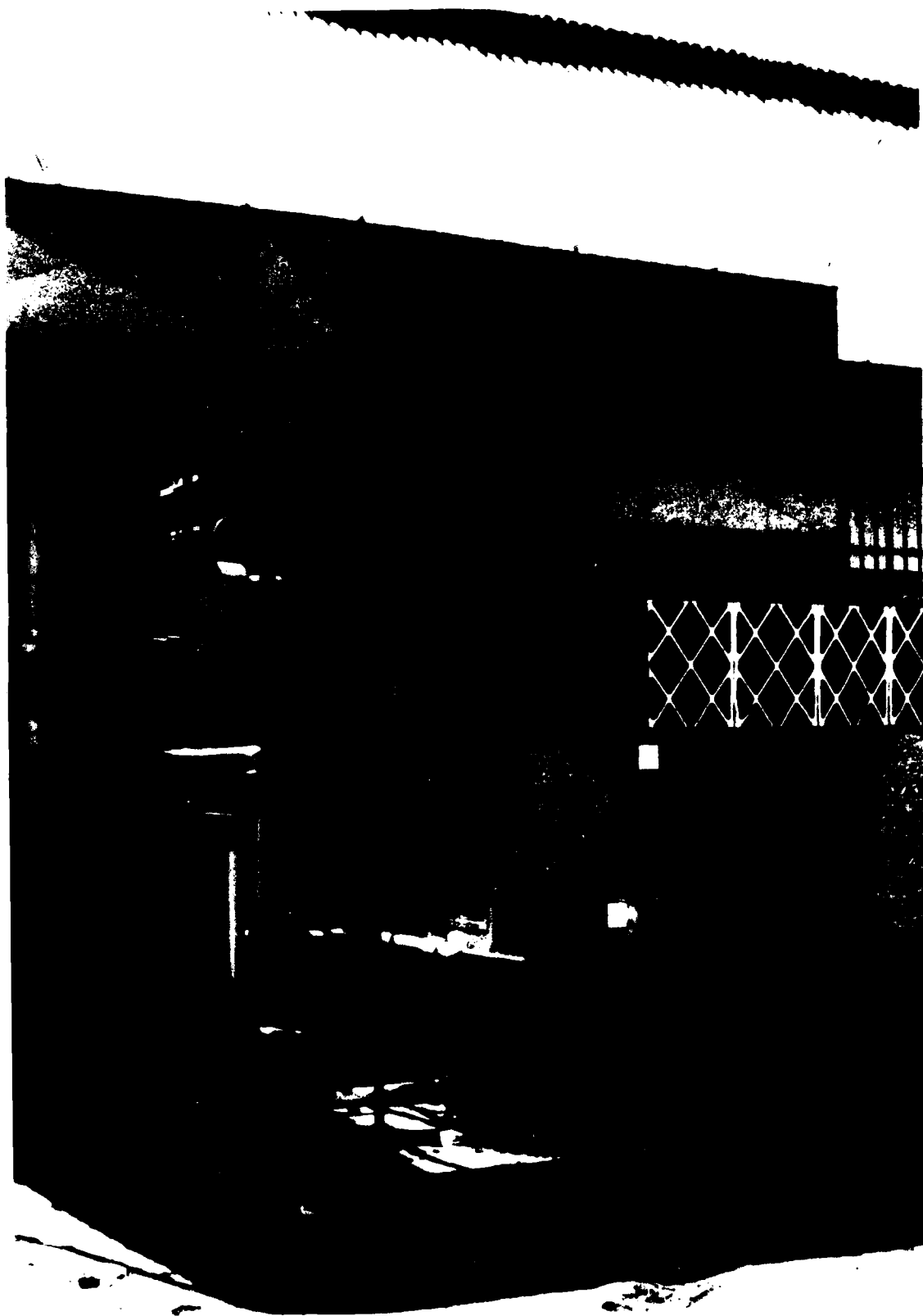


Figure 3. Air handler unit.

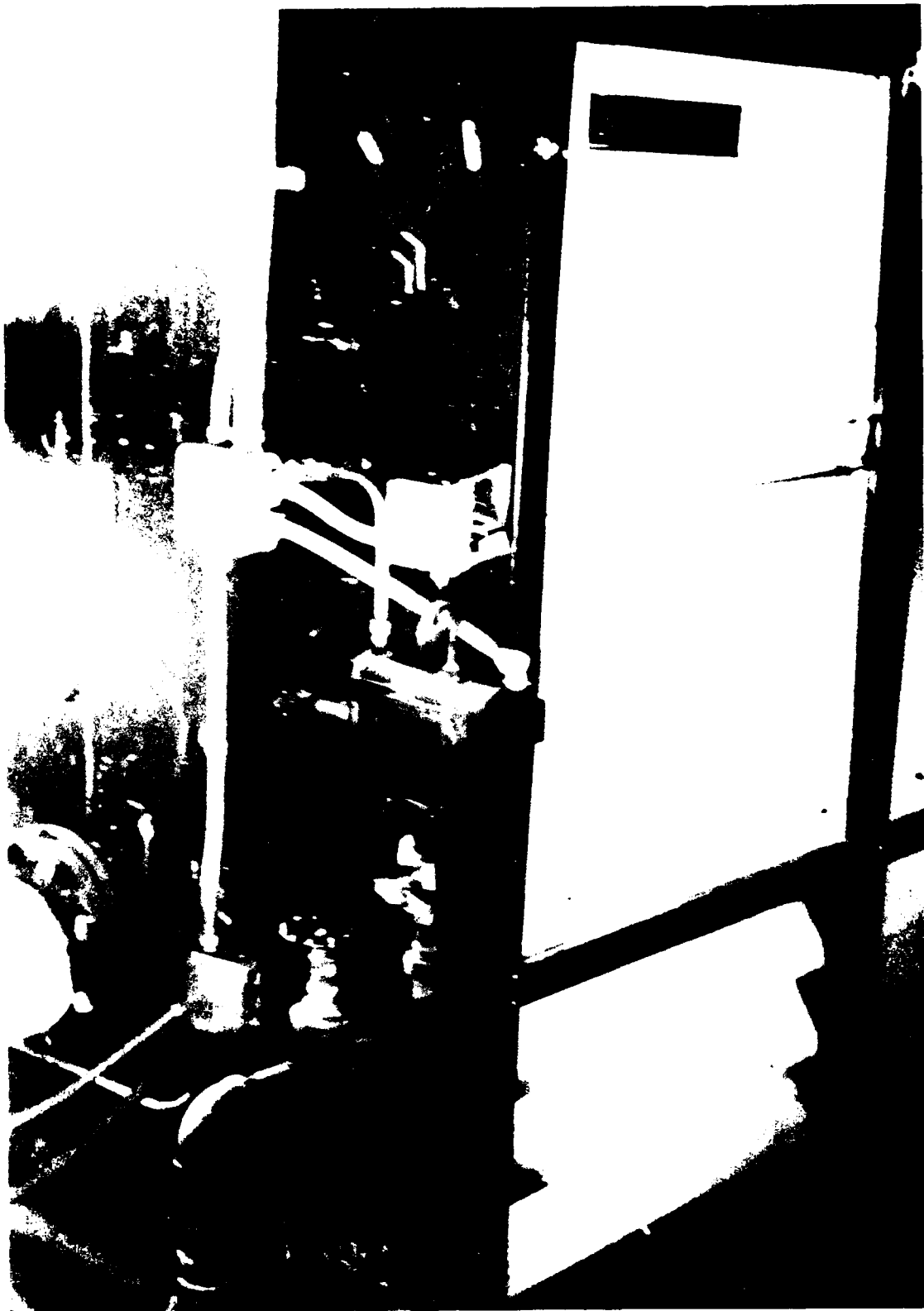


Figure 2. Boiler, model no. 309.

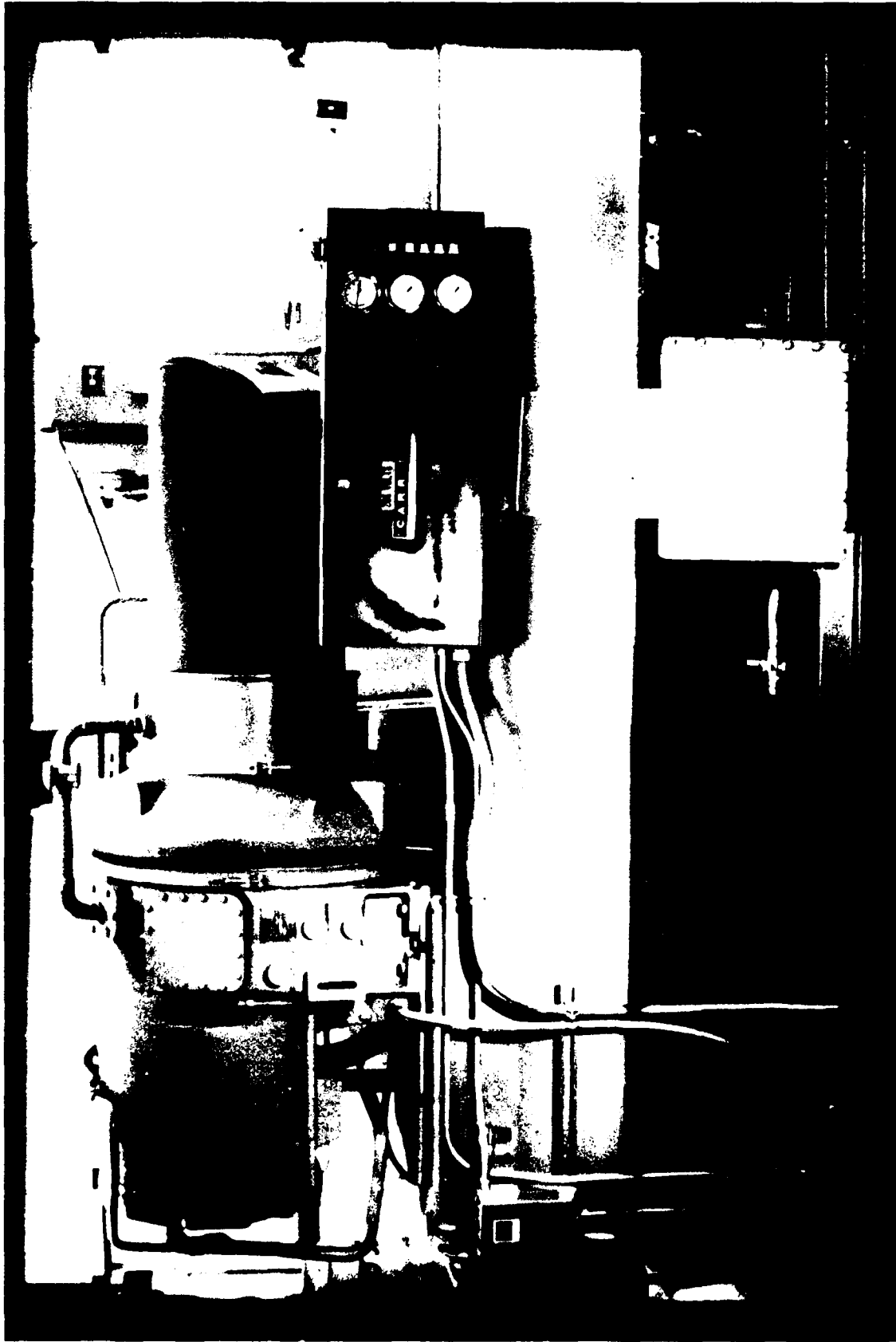


Figure 1. 160-ton chiller, Model no. 19DG160.

Appendix

DETAILS ON THE HARDWARE AND SOFTWARE OF THE AC256

HARDWARE CAPABILITIES

- Thirty-two definable inputs for temperature, pressure, relative humidity or contact closures sensing.
- Sixteen digital outputs (relay closures) to control chillers, AHUs or boilers.
- Each master can control up to 16 slaves. Slaves consist only of an I/O unit with no intelligence. The intelligence is only at the master units.
- The maximum configuration network is a 16 x 16 matrix of masters and slaves. A total of 8,192 inputs and 4,096 outputs.
- The AC256M uses the Motorola family of microprocessor called the 6800 which has been proven to be a very reliable system.
- A battery back-up is included to maintain the programs and the time data for 3 hours during electrical power outages.

SOFTWARE CAPABILITIES

A very simple English control language is used. Each program area is analogous to a cylindrical drum with program lines and a pointer. There is capacity for 320 drums. The user can program the machine to suit his needs. There are no canned control programs. The manufacturer provides an installation guide, if requested, that documents some control programs. With a minimum modification these were applied at the evaluation site.

As an example of the machine flexibility one of the commands will be discussed. The "ASSIGN" command is used to define the inputs and outputs. Inputs and outputs will have a connection and a name assigned.

Command Format for the Outputs

ASSIGN OM,1-16 NAME

OM - is to define an output in master number M
1-16 - is the available outputs in one master
NAME - any eight characters

To define the third output in a system with only one master, the following command is used:

ASSIGN 01,3 CHILLER

Now relay number three in the output will be used to control the chiller and can be referenced in the programs by the new name "CHILLER" (see example in the end of the Appendix).

Examples for the Inputs

You identify the inputs in the same format, although there are 32 inputs. But instead of using the letter O, you must pick one of four letters, indicating the way you will be using the input:

V - to read as a voltage

T - to read it as a temperature (number of degrees fahrenheit)

D - to read it digitally (on or off)

C - to read it as a counter (number of pulses sensed in the most recent interval)

Examples

ASSIGN C1,1 KWPULSE

ASSIGN T1,2 EXT-TEMP

ASSIGN T1,3 INT-TEMP

ASSIGN D1,4 OVERRIDE

In the second example: ASSIGN T1,2 EXT-TEMP, input 2 for master 1 is a temperature sensor measuring external temperature.

This demonstrates the flexibility of the AC256 in which inputs and outputs can be named and categorized in any order.

At the same time there is protection as well flexibility. The AC256M has 3 levels of security. The higher the number the less the restriction. Therefore, level 3 will let the operator use all the AC256's features, even program in or delete personal passwords. Level 2 lets the operator analyze or change the AC256's operation, reprogram it, or erase part or all of its memory. In level 1 the operator can find out what the AC256 is doing but not affect the AC256's operation in any way.

To demonstrate the simplicity in programming the AC256 an actual program in use at the Thompson Laboratory will be shown. The example that follows is currently being used to control the chiller.

DISTRIBUTION LIST

AF HQ AFLEY Washington, DC; LEEEU (Aimone), Wash., DC
 AFB AFCS DEO (Corbett), Scott AFB, IL; AFESC/TST, Tyndall FL; AFSC/DEE, Andrews AFB, Wash, DC;
 DET Wright-Patterson OH; HQ AFLC/DEE (EMCS Mgr), Wright-Patterson AFB, OH; HQ ATC/DEM
 (Ling), Randolph AFB, TX; HQ PACAF/DEE (EMCS Mgr), Hickam AFB, HI; HQ SAC/DEE (Butters),
 Offutt AFB, NE; HQ SAC/DEER, Offutt AFB, NE; HQ SAC/DEM (Tonsi), Offutt AFB, NE; HQ
 SPACECOM/DE (Moytinia), Peterson AFB, CO; HQ TAC/DEE (Scercy), Langley AFB, VA; HQ
 TAC/DEM (White), Langley AFB, VA; MAC/DEE (West), Scott AFB, IL; MAC/DEM (Kosch), Scott AFB,
 IL; Scol of Engrng (AFIT/DET); Wright-Patterson, Energy Conversion, Dayton, OH
 AFESC DEB (Stother), Tyndall AFB, FL; HQ, RDVA & RDVCW
 USAF-AAC DEE, Elmendorf AFB, AK
 ARMY BMDSC-RE (H. McClellan) Huntsville AL; Chief of Engineers DAEN-MPE-E Washington DC; Chief
 of Engineers DAEN-MPO-U, Washington DC; FESA-EN, Fort Belvoir, VA
 ARMY - CERL Energy Systems, Champaign, IL; Library, Champaign IL
 ARMY CORPS OF ENGINEERS DAEN-MPC-C (Wharry), Wash., DC; DAEN-MPE-E (Brake), Wash., DC;
 DAEN-MPE-E (McCarthy), Wash., DC; DAEN-MPO-U (Walton), Wash., DC; ORLCD-I (R Dockery)
 Louisville, KY
 ARMY DEPOT FAC ENGR, CODE SDSLE-SF, Letterkenny Army Dp, Chambersburg.
 ARMY ENG DIV EUDED-TM (O'Malley), HNDED-ME (Carlen), Huntsville, AL; HNDED-ME (DeShazo),
 Huntsville, AL; HNDED-ME (Herden), Huntsville, AL; HNDED-ME (Holland), Huntsville, AL;
 HNDED-ME (Wilcox), Huntsville, AL; HNDED-PM (Brown), Huntsville, AL; HNDED-PM (Ganus),
 Huntsville, AL; MRDED-TM (Beranck), Omaha, NE; MRDED-TM (Jones), Omaha, NE; NADCO-CM
 (Eng), New York, NY; NADEN-TM (Stuart), New York, NY; NPDEN TL (Wottlin), Portland, OR;
 ORDED-T, (Norman), Cincinnati, OH; PODED-T (Nakasone), Ft. Shafter, HI; SADCO-CC (Mindel),
 Atlanta, GA; SADEN-TE (Smith), Atlanta, GA; SPDED-TG (Kishaba) San Francisco, CA; SWDED-M
 (Powell), Dallas, TX
 ARMY ENGR DIST. CO, Tulsa, OK; MRKED-DM (Rabuse), Kansas City, MO; MRKED-M (McCollum),
 Kansas City, MO; MROCD-SM (Hall), Omaha, NE; MROCD-SM (O'Brien), Omaha, NE; MROED-DC
 (Sawick), Omaha, NE; NABCO-S (Meisel), Baltimore, MD; NABEN-D (Kelly), Baltimore, MD;
 NANCO-C (Spector), New York, NY; NANEN-DM (Kessenides), New York, NY; NAOEN-MA
 (Daughety), Norfolk, VA; NAOOP-C (Herndon), Norfolk, VA; NPSEN-DB (Eason), Seattle, WA;
 ORLED-D (Pfeifer), Louisville, KY; SAMCO-SI (Rawls) Mobile, AL; SAMEN-C (Anderson), Mobile, AL;
 SAMEN-CI (Tunnell), Mobile, AL; SASEN-DF (Plunkett), Savannah, GA; SASEN-MA (Grimes),
 Savannah, GA; SCD-SB (Stone), Savannah, GA; SPKCO-C (Del Porto), Sacramento, CA; SPKCO-C
 (Evans), Sacramento, CA; SPKED-M (Lowell), Sacramento, CA; SPKED-M (Stoner), Sacramento, CA;
 SPLCO-CS (Molina), Los Angeles, CA; SWFCD-ST (Ready), Ft. Worth, TX; SWFCD-ST (Wood), Ft.
 Worth, TX; SWFED-DM (Story), Ft. Worth, TX; SWFED-DM (Wike), Ft. Worth, TX
 ADMIN SUPU PWO, BAHRIAN
 ASO CO (Code PWB-7), Philadelphia, PA
 BUMED Code 3212, Washington DC
 CINCLANTFLT Code N47, Norfolk, VA
 CINCPACFLT Code 443, Energy Coord, Pearl Harbor, HI
 CNAVRES Code 4732, New Orleans, LA
 CNET Code N-10B3), NAS Pensacola, FL
 CNM Code MAT-04, Washington, DC; Code MAT-08E, Washington, DC
 CNO Code OP-413 Wash, DC; OP-098, Washington, DC
 COMFLEACT, OKINAWA PWD - Engr Div, Sasebo, Japan; PWO, Sasebo, Japan
 COMNAV DIST Energy Conserv., Washington DC
 COMNAVLOGPAC Code 4318, Pearl Harbor, HI
 DEFFUELSUPPCEN DFSC-OWE (Term Engrng) Alexandria, VA
 DTNSRDC Code 401.4, Energy Conserv, Bethesda, MD
 FLEASWTRACENPAC CO (Code N3C) San Diego, CA
 FLTCOMBATDIRSACT Code 40A, Virginia Beach, VA
 KWAJALEIN MISRAN BMDSC-RKL-C
 LIBRARY OF CONGRESS Washington, DC (Sciences & Tech Div)
 MARINE CORPS BASE FAC Engr, Camp H. M. Smith, HI
 MARINE CORPS HQS Code LFF Washington DC
 MCAS CO (Energy Conserv), Jacksonville, NC; PWD - Utilities Div, Iwakuni, Japan; PWO, Iwakuni, Japan
 MCRD CG, San Diego, Ca
 MCAS Code 3JA2, Yuma, AZ
 NAF CO (Code 18), Midway, Is.; NAF/CO, Lajes, Azores
 NAS (Code 18E) Jacksonville, FL; CO (AOT), Whidbey Island, Wa; CO (Code 18.1), Bermuda; CO (Code
 18100); CO (Code 18100), Cecil Field, FL; CO (Code 18100), Chase Field, Beeville, Tx; CO (Code 18100),

Fallon, NV; CO (Code 1815), Corpus Christi, TX; CO (Code 1824), Lakehurst, NJ; CO (Code 182H), Key West, FL; CO (Code 183U), Miramar, San Diego, Ca; CO (Code 184), Moffett Field, CA; CO (Code 189720), Brunswick, ME; CO (Code 70), Glenview, IL; CO (Code 70), Marietta, GA; CO (Code 70), So. Weymouth, MA; CO (Code 71), Willow Grove, PA; CO (Code 721), Belle Chasse LA; Code 18010, Kingsville, TX; Code 18A00, Whiting Fld, Milton, FL; Code 18B00, Lemoore, CA; Code 18D00, Memphis 84, Millington, TN; Code 18E, Oceana, Virginia Beach, VA; Code 70, Atlanta, Marietta GA; Code 70A, Dallas, TX; PWD - Engr Div, Gtmo, Cuba; PWO Key West FL; PWO., Moffett Field CA; SCE, Cubi Point, R.P; Weapons Offr, Alameda, CA
 NATL BUREAU OF STANDARDS Thermal Anal Gp, Wash, DC
 NATNAVMEDCEN Code 43, Energy Conserv (PWO) Bethesda, MD
 NAVACT CO (Code A171P), London, UK
 NAVACTDET PWO, Holy Lock UK
 NAVAIRDEVEN CO (Code 8323), Warminster, PA; Chmielewski, Warminster, PA
 NAVAIRPROPTTESTCEN CO (Code PW-3), Trenton NJ; CO, Trenton, NJ
 NAVAIRTESTCEN PATUXENT RIVER Code PW8L1, Patuxent River, MD
 NAVAL HOME PWO, Gulfport, MS
 NAVAVIONICFAC Code B 732
 NAVCOASTSYSCEN CO (Code 352), Panama City, FL
 NAVCOMMAREAMSTRSTA CO (Energy Conserv), Naples, It.
 NAVCOMMAREAMSTRSTA Code 41, Norfolk, VA
 NAVCOMMSTA CO (Code 20) San Diego, CA; CO (Code 401), Nea Makri, Greece; CO (PWD), Exmouth, Australia; CO, San Miguel, R.P.; Code 31, Stockton, CA; PWD - Maint Control Div, Diego Garcia Is.; PWO, Exmouth, Australia; SCE, Thurso, Scotland
 NAVCOMMUNIT CO (Code 50), East Machias, ME
 NAVCONSTRACEN Curriculum Instr, Stds Offr, Gulfport MS
 NAVDET OIC (Energy Conserv), Souda, Bay, Crete
 NAVEDUTRACEN CO, Code 44, Newport RI
 NAVELEXSYSCOM ELEX 1033 Washington, DC
 NAVFAC APWO, Pacific Beach, WA; CO (Code 04) Coos Head, Charleston, Or; CO (Code 05) Centerville Beach Fernadale, CA; CO (Code 300), Antigua; CO (Code 50A), Brawdy Wales, UK; CO (Energy Conserv), Big Sur, CA; M & O Officer Bermuda
 NAVFACENGCOM Alexandria, VA; Code 03 Alexandria, VA; Code 03T (Essoglou) Alexandria, VA; Code 04 Alexandria, VA; Code 04T1 (Watkins), Alexandria, VA; Code 04T7A (Stickley), Alexandria, VA; Code 05, Alexandria, VA; Code 051A Alexandria, VA; Code 05D1 (Bersson), Alexandria, VA; Code 08, Alexandria, VA; Code 09M54, Tech Lib, Alexandria, VA; Code 11, Alexandria, VA; Code 1112E, Alexandria, VA; Code 1113, Alexandria, VA; Code 111B (Hanneman), Alexandria, VA; Code 4T2B, Alexandria, VA
 NAVFACENGCOM - CHES DIV, Code 04, Wash, DC; Code 05, Wash, DC; Code 10/11, Washington, DC; Code 112, Wash, DC; Library, Washington, D.C.
 NAVFACENGCOM - LANT DIV, Code 04 Norfolk VA; Code 05, Norfolk, VA; Code 11, Norfolk, VA; Code 1112, Norfolk, VA; Library, Norfolk, VA; Norfolk, VA
 NAVFACENGCOM - NORTH DIV, CO; Code 04 Philadelphia, PA; Code 04AL, Philadelphia PA; Code 05, Phila, PA; Code 11, Phila PA; Code 111 Philadelphia, PA; Code 405 Philadelphia, PA
 NAVFACENGCOM - PAC DIV, Code 04 Pearl Harbor HI; Code 05, Pearl Harbor, HI; Code 11 Pearl Harbor HI; Code 111, Pearl Harbor, HI; Code 402, RDT&E, Pearl Harbor HI; Library, Pearl Harbor, HI
 NAVFACENGCOM - SOUTH DIV, Code 04, Charleston, SC; Code 05, Charleston, SC; Code 11, Charleston, SC; Code 1112, Charleston, SC; Code 405 Charleston, SC; Library, Charleston, SC
 NAVFACENGCOM - WEST DIV, Code 04, San Bruno, CA; Code 05, San Bruno, CA; Code 11 San Bruno, CA; Code 405 San Bruno, CA; Library, San Bruno, CA; RDT&ELO San Bruno, CA; San Bruno, CA
 NAVFACENGCOM CONTRACTS Contracts, AROICC, Lemoore CA; OICC, Kings Bay, GA; ROICC Code 495 Portsmouth VA
 NAVFUELDEP OIC (Energy Conserv), JAX, FL
 NAVHOSP APWO (Code 13), Beaufort SC; CO Long Beach, CA; CO, Millington, TN; Code 310, Portsmouth, VA; Code 93, Portsmouth, VA
 NAVMAG PWD - Engr Div, Guam; SCE, Guam
 NAVOBSY Code 67, Washington DC
 NAVOCEANSYSCEN Commander (Code 411), San Diego, CA
 NAVORDEFAC CO (Code 66), Sasebo, Japan
 NAVORDMISTESTFAC PWD - Engr Dir, White Sands, NM
 NAVORDSTA CO (Code 0931), Louisville, KY; Code 092, Indian Head, MD; PWD - Dir, Engr Div, Indian Head, MD
 NAVORDSYSCOM Code SPL-631
 NAVPGSCOL Code 43B, Monterey, CA
 NAVPHIBASE PWO Norfolk, VA
 NAVPLANTREP Hercules Inc., Magna, UT
 NAVREGMEDCEN CO (Code A09) - Engr Div, Phila., PA
 NAVRESREDCOM Commander (Code 072), San Francisco, CA

NAVSCOLCECOFF C35 Port Hueneme, CA
 NAVSCSCOL CO (Code 50), Athens, GA
 NAVSEASYSCOM PMS-396 33 Washington DC
 NAVSECGRUACT CO (Code 30), Puerto Rico; CO (Code 40B), Edzell, Scotland; CO (Code N60),
 Homestead, FL; CO (Energy Conserv.), Sonoma, CA; CO (Energy Conserv.) Winter Harbor, ME; Code 40,
 Chesapeake, VA; PWD, ADAK, AK; PWO, Adak AK; PWO, Torri Sta, Okinawa
 NAVSECGRUCOM Energy Conserv., Washington DC
 NAVSECSTA Code 540, Washington DC; PWD - Engr Div, Wash., DC
 NAVSHIPYD CO (Code 405); Code 402.4, Philadelphia PA; Code 410, Mare Is., Vallejo CA; Code 440.8,
 Puget Sound, Bremerton, WA; Code 457 (Maint. Supr.) Mare Island, Vallejo CA; Commander (Code 406),
 Portsmouth, NH; PWD (Code 400.03), Charleston SC; PWD - Utilities Supt, Code 903, Long Beach, CA;
 PWO Charleston Naval Shipyard, Charleston SC; PWO, Mare Is.; SCE, Pearl Harbor HI
 NAVSURFWPNCEN Code W42 (R. Ponzetto), Dahlgren, VA
 NAVSTA (Code 50A) Rodman, Panama Canal; CO (Code 18410), Mayport, FL; CO (Code 413), Grmo, Cuba;
 CO (Code 52), Brooklyn NY; CO (PWD), Keflavik, Iceland; CO (PWD), Rota, Spain; Code 0D3, San
 Diego, CA; Energy Conserv., ADAK, AK; Maint. Cont. Div., Guantanamo Bay Cuba; SCE, Subic Bay,
 R.P.
 NAVSUBASE CO (Code 803), Groton, CT; PWO Bangor, Bremerton, WA
 NAVSUPPACT (Code PW7) Naples, Italy; CO (Code 413), Seattle, WA; CO (Code 81), Mare Island, Vallejo,
 CA; CO (Code N52), New Orleans, LA; CO, Naples, Italy; PWO Naples Italy
 NAVSUPPBASE CO (Energy Conserv) Kings Bay, GA
 NAVSUPPFAC CO (Energy Conserv) Diego Garcia I; Code 02, Thurmont, MD
 NAVSUPPO CO (APWO), La Maddalena, Italy
 NAVSURFWPNCEN Code WO-5, Dahlgren VA
 NAVTELCOMMCOM Code 05, Washington DC
 NAVUSEAWARENGSTA CO (Code 073E2), Keyport, WA
 NAVWPNCEN Commander (Code 2635), China Lake, CA
 NAVWPNSTA CO (Code 09221), Concord, CA; CO (Energy Conserv) Yorktown, VA; CO (Energy Conserv),
 Colts Neck, NJ; Code 0911, Seal Beach CA
 NAVWPNSUPPCEN CO (Code 092E), Crane, IN
 NCBC CO (Code 80), Port Hueneme, CA; CO (Energy Conserv), Davisville, RI
 NOAA Library Rockville, MD
 NRL PWO Code 25301, Washington, DC
 NSC CO (Code 46A) San Diego, CA; CO (Code 70A), Puget Sound, WA
 NSD CO (Code 50E)
 NTC CO (Code NAC50F) Orlando, FL
 NUSC DEI CO (Code 5204), Newport, RI; Code 5202 (S. Schady) New London, CT
 ONR CO (Code 701) Pasadena, CA
 PACMISRANFAC Code 7032, HI Area, Kekaha, HI
 PMTC Commander (Code 6200-3), Point Mugu, CA
 PWC CO (Code 100E), San Diego, CA; CO (Code 100E3), Oakland, CA; CO (Code 153), Guam; CO (Code
 30), Pearl Harbor, HI; CO (Code 610), Pensacola, FL; CO (Code 613), San Diego, CA; CO Code 100E,
 Oakland, CA; Code 100A, Great Lakes, IL; Code 105, Oakland, CA; Code 116, Yokosuka, JA; Code 101
 (Library), Oakland, CA; Code 154 (Library), Great Lakes, IL; Code 600A Norfolk, VA; Code 610, San
 Diego CA; Code 610, Subic Bay RP; Library, Code 120C, San Diego, CA; Library, Guam; Library, Norfolk,
 VA; Library, Pearl Harbor, HI; Library, Pensacola, FL; Library, Subic Bay, R.P.; Library, Yokosuka JA;
 CO, NAS Pensacola, FL; Utilities Officer, Guam
 SPCC Code 763, Mechanicsburg, PA
 SUPANX PWO, Williamsburg VA
 SUPSHIP ADMINO, San Francisco, CA; Code 901
 USAF AFRCE CR (Walton), Dallas, TX; AFRCE ER (Burns), Atlanta, GA; AFRCE M-X (Stevens), Norton
 AFB, CA; AFRCE WR (Lowry), San Francisco, CA
 USAFE HQ DEE (EMCS Mgr), Ramstein AFB, Germany
 USNA Code 170, Annapolis, MD
 ARIZONA Kroelinger Tempe, AZ
 CLEMSON UNIV Col Arch., Egan, Clemson, SC
 FRANKLIN INSTITUTE M. Padusis, Philadelphia PA
 IOWA STATE UNIVERSITY Dept Arch, McKrown, Ames, IA
 LAWRENCE BERK LAB Window & Lighting Prog Berkeley, CA
 LOS ALAMOS SCI LAB Solar Energy Gp, Los Alamos, NM
 MIT Cambridge MA (Rm 10-500, Tech Reports, Engr. Lib)
 OAK RIDGE NATL LAB T. Lundy, Oak Ridge, TN
 UNIVERSITY OF FLORIDA Dept Arch., Morgan, Gainesville, FL
 UNIVERSITY OF NEW HAMPSHIRE Elec. Engr. Depot, Dr. Murdoch, Durham, NH
 UNIVERSITY OF WASHINGTON Inst. for Envir. Studies

GARD INC. Dr. L. Holmes, Niles, IL
PG&E Library, San Francisco, CA
SANDIA LABORATORIES Library Div., Livermore CA
UNITED KINGDOM LNO, USA Meradcom, Fort Belvoir, VA
FISHER San Diego, Ca

PLEASE HELP US PUT THE ZIP IN YOUR
MAIL! ADD YOUR FOUR NEW ZIP DIGITS
TO YOUR LABEL (OR FACSIMILE),
STAPLE INSIDE THIS SELF-MAILER, AND
RETURN TO US.

(fold here)

DEPARTMENT OF THE NAVY

NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME CALIFORNIA 93043-5003

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, \$300
1 IND-NCEL 2700 4 (REV 12-73)
0930-LL-L70-0044

POSTAGE AND FEES PAID
DEPARTMENT OF THE NAVY
DOD-316



Commanding Officer
Code L14
Naval Civil Engineering Laboratory
Port Hueneme, California 93043-5003

INSTRUCTIONS

The Naval Civil Engineering Laboratory has revised its primary distribution lists. The bottom of the mailing label has several numbers listed. These numbers correspond to numbers assigned to the list of Subject Categories. Numbers on the label corresponding to those on the list indicate the subject category and type of documents you are presently receiving. If you are satisfied, throw this card away (or file it for later reference).

If you want to change what you are presently receiving:

- Delete - mark off number on bottom of label.
- Add - circle number on list.
- Remove my name from all your lists - check box on list.
- Change my address - line out incorrect line and write in correction (ATTACH MAILING LABEL).
- Number of copies should be entered after the title of the subject categories you select.

Fold on line below and drop in the mail.

Note: Numbers on label but not listed on questionnaire are for NCEL use only, please ignore them.

Fold on line and staple.

DEPARTMENT OF THE NAVY

NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

OFFICIAL BUSINESS

PENALTY FOR PRIVATE USE, \$300

1 IND-NCEL-2700/4 (REV. 12-73)

0930-LL-L70-0044

POSTAGE AND FEES PAID
DEPARTMENT OF THE NAVY
DOD-316



Commanding Officer
Code L14
Naval Civil Engineering Laboratory
Port Hueneme, California 93043

DISTRIBUTION QUESTIONNAIRE

The Naval Civil Engineering Laboratory is revising its primary distribution lists.

SUBJECT CATEGORIES

1 SHORE FACILITIES

- 2 Construction methods and materials (including corrosion control, coatings)
- 3 Waterfront structures (maintenance/deterioration control)
- 4 Utilities (including power conditioning)
- 5 Explosives safety
- 6 Construction equipment and machinery
- 7 Fire prevention and control
- 8 Antenna technology
- 9 Structural analysis and design (including numerical and computer techniques)
- 10 Protective construction (including hardened shelters, shock and vibration studies)
- 11 Soil/rock mechanics
- 13 BEQ
- 14 Airfields and pavements
- 15 ADVANCED BASE AND AMPHIBIOUS FACILITIES
- 16 Base facilities (including shelters, power generation, water supplies)
- 17 Expedient roads/airfields/bridges
- 18 Amphibious operations (including breakwaters, wave forces)
- 19 Over the Beach operations (including containerization, materiel transfer, lighterage and cranes)
- 20 POL storage, transfer and distribution
- 24 POLAR ENGINEERING
- 24 Same as Advanced Base and Amphibious Facilities, except limited to cold region environments

28 ENERGY/POWER GENERATION

- 29 Thermal conservation (thermal engineering of buildings, HVAC systems, energy loss measurement, power generation)
- 30 Controls and electrical conservation (electrical systems, energy monitoring and control systems)
- 31 Fuel flexibility (liquid fuels, coal utilization, energy from solid waste)
- 32 Alternate energy source (geothermal power, photovoltaic power systems, solar systems, wind systems, energy storage systems)
- 33 Site data and systems integration (energy resource data, energy consumption data, integrating energy systems)

34 ENVIRONMENTAL PROTECTION

- 35 Solid waste management
- 36 Hazardous/toxic materials management
- 37 Wastewater management and sanitary engineering
- 38 Oil pollution removal and recovery
- 39 Air pollution
- 40 Noise abatement

44 OCEAN ENGINEERING

- 45 Seafloor soils and foundations
- 46 Seafloor construction systems and operations (including diver and manipulator tools)
- 47 Undersea structures and materials
- 48 Anchors and moorings
- 49 Undersea power systems, electromechanical cables, and connectors
- 50 Pressure vessel facilities
- 51 Physical environment (including site surveying)
- 52 Ocean based concrete structures
- 53 Hyperbaric chambers
- 54 Undersea cable dynamics

TYPES OF DOCUMENTS

- 85 Techdata Sheets 86 Technical Reports and Technical Notes
83 Table of Contents & Index to TDS

- 82 NCEL Guide & Updates ☐ None—
91 Physical Security remove my name

END

FILMED

7-85

DTIC